XXIII. "On the Thermal Effects of Fluids in Motion."—Part IV. By J. P. Joule, LL.D., F.R.S., and Professor W. Thomson, F.R.S. Received June 19, 1862.

(Abstract).

A brief notice of some of the experiments contained in this paper has already appeared in the 'Proceedings.' Their object was to ascertain with accuracy the lowering of temperature, in atmospheric air and other gases, which takes place on passing them through a porous plug from a state of high to one of low pressure. Various pressures were employed, with the result (indicated by the authors in their Part II.) that the thermal effect is approximately proportional to the difference of pressure on the two sides of the plug. The experiments were also tried at various temperatures, ranging from 5° to 98° Cent., and have shown that the thermal effect, if one of cooling, is approximately proportional to the inverse square of the absolute temperature. Thus, for example, the refrigeration at the freezing temperature is about twice that at 100° Cent. In the case of hydrogen, the reverse phenomenon of a rise of temperature on passing through the plug was observed, the rise being doubled in quantity when the temperature of the gas was raised to 100°. This result is conformable with the experiments of Regnault, who found that hydrogen, unlike other gases, has its elasticity increased more rapidly than in the inverse ratio of the volume. The authors have also made numerous experiments with mixtures of gases, the remarkable result being that the thermal effect (cooling) of the compound gas is less than it would be if the gases after mixture retained in integrity the physical characters they possessed while in a pure state.

XXIV. "On the Spectra of Electric Light, as modified by the Nature of the Electrodes and the Media of Discharge." By the Rev. T. R. Robinson, D.D., F.R.S. Received June 19, 1862.

(Abstract.)

The author, after referring briefly to the researches of previous inquirers, and the hypothesis now generally adopted, that the bright lines observed in these spectra depend so absolutely on the chemical nature of the substances present that their occurrence is an unerring test of that presence, expresses his belief that it cannot be admitted

in its full extent without much more decisive proof than has yet been afforded. It assumes,

1. That each substance has a set of lines peculiar to itself.

2. That those lines are not produced or modified by any molecular agent except heat.

3. That the spectrum of one substance is in nowise modified by the presence of another; and in such cases both spectra coexist independently, and are merely superposed.

4. As may be inferred from 2, that electricity does not make matter luminous directly, but only by heating it; so that the electric spectrum differs in nothing from that produced by heat of sufficient intensity.

His attention was directed to this subject several years ago by the difference of colour of discharges in carbonic oxide at common and diminished pressure; and the results of his experiments appear to show that none of these four points is universally true.

His apparatus consisted of a powerful induction machine, with which a Leyden jar was connected; of prisms, first one of 45°, afterwards one of 60° (whose deviations were reduced to the scale of the first); and of an optical theodolite, in which a collimator with a variable slit gives the beam whose spectrum is observed. He points out an important defect of this arrangement, and discusses the probable liabilities to error proceeding from the graduation reading only to minutes, and from other sources of uncertainty.

The media of discharge were air, nitrogen, oxygen, hydrogen, and carbonic oxide, to which were added in some instances the vapours of mercury, phosphorus, and bisulphuret of carbon. For electrodes, 23 metals and graphite were used—15 with each of the five gases at common pressure and at one of 0°·2, the others only with some of them. In all, 185 *different* spectra were measured, of which 93 were at common pressure.

At common pressure the spectra show a number of bright lines on a coloured ground, the light of which is in general stronger towards the red than the violet end, and strongest in the green. In some this ground is so bright as to efface all but the most luminous lines: this is especially the case with hydrogen. Of the lines, some are very brilliant; but they range in light down to the very lowest degree of faintness, such that (at least with the author's apparatus) they can only be seen when the room is entirely dark, and are bisected with

great difficulty. They vary also in width, from a mere hair's breadth to six or seven times the apparent width of the slit.

On exhausting the tube in which the discharge is made, at first the only change is that the brilliant lines lose a little of their lustre, till at pressures varying from 3° to $0^{\circ}\cdot 5$ the spectrum rather suddenly fades away, sometimes leaving only a suspicion of one or two lines; with others the least-refrangible rays vanish, while the violet remain, though very faint, especially with aluminium. In hydrogen spectra the three bright bands of this gas vanish at unequal densities; and it is remarkable that this occurs when the gas is diluted to the same proportions by mixing air with it.

Exhausting yet further, this transition spectrum becomes again bright; fresh lines appear, and it is changed into a new one, which, however, is never as splendid as that at common pressure, especially at the red end, and in which the very brilliant lines are less frequent. This want makes the difference between the two kinds of spectra seem greater than it really is. Fewer lines are visible in the rarefied media, and of these about four-tenths are not found in the spectra of common pressure.

If the tables in which the measures are given be examined in reference to the points alluded to as doubtful, it will be obvious,

1. That many lines are found in *all the gases*, and in *many, perhaps all* the metals: the existence of such lines must be independent of the chemical nature of electrodes or media; it is otherwise with their brightness, which may be intense with one substance and feeble with another. This unchemical origin is still more clearly shown by a modified experiment of Plücker, where the discharge is made by the induction of glass without the presence of any metal. When *the same* glass vessel was filled in succession with nitrogen, oxygen, and hydrogen, though not above twenty-three lines were seen in its capillary tube, and those very faint, yet more than half the number were common to two of the gases, or to the three. These might perhaps be referred to soda or lead detached from the glass; but some of them are not found in those spectra.

2. The difference between the common-pressure, transition, and rarefied spectrum shows that the character and even the existence of certain lines depend on the mere density of the medium, the chemical circumstances remaining unchanged.

3. That the spectra are not merely superposed without change is

evident from several facts. The spectra of air do not in every case show all the lines of oxygen and nitrogen, and occasionally have some not visible in either of them: the spectrum of graphite in oxygen is quite different from those of carbonic oxide. There is even reason to believe that for certain lines the actions of bodies may be antagonistic. The spectrum of mercury electrodes and mercury vapour showed 48 lines, and the author expected that the spectra for any gas with mercury electrodes would add to those of mercury the peculiar lines of that gas, which could thus be certainly determined. In the nitrogen spectrum, however, 20 of the mercurial lines had disappeared, in the hydrogen 18, and in the carbonic oxide 13.

4. The brilliancy or visibility of the lines is very little increased by greatly augmenting the heating power of the discharge. The two halves of the induction machine can be made to act either consecutively for tension, or collaterally for quantity. In the latter case the quantity is doubled, and therefore the heating power quadrupled. When the apparatus is so used, the violet bands are something brighter, but not so much so as to be noticed by an unpractised observer. The red and green show no appreciable difference; but the author is inclined to think the change may be greater in the ultra-violet part. He proposes, however, to repeat the experiment with coils of much greater power as to quantity. If electricity can produce thermic vibrations by its transmission, there seems no *à priori* reason why it cannot produce luminous ones; and no evidence that it cannot is known to him.

It seems to follow from these observations that the tendency to show such lines belongs to matter in general, but that different forms of it have different powers of manifesting that tendency, and that those powers may sometimes interfere. If this be confirmed by further research, the result will be that, though the *electric* spectrum may give useful indications to the analyst, it should never be his sole dependence, or be trusted without full cognizance of the conditions which may affect its indications.

XXV. "On Fermat's Theorem of the Polygonal Numbers."—Second Communication. By the Right Hon. Sir FREDERICK POLLOCK, F.R.S., Lord Chief Baron. Received June 19, 1862.

(Abstract.)

The object of this paper is to show the result of combining the three series (which have been the subject of previous communica-